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AGRICULTURAL MEMORANDUM No. 953

An Assessment of the Frequency of High Temperatures and Low Windspeeds.

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Introduction

In animal or poultry houses where the maximum ventilation rate is solely dependent on building design there are times when meteorological factors will impose conditions which will disturb the comfort of the animal with a resultant decrease in live weight gain and give problems with hygiene.

This memorandum assesses the frequency of occurance of high temperatures combined with low windspeeds at three meteorological sites in England, and has particular reference to buildings which rely on automatically controlled natural ventilation (ACNV) systems.

Environmental Considerations

From the planning stage it is essential to form a clear idea about which form of ventilation system will be best suited to any particular form of husbandry. The siting of an animal house will have a direct influence on whether ACNV, stack effect (Bruce, 1973) and/or a fan driven system will be incorporated to produce the required degree of air flow and temperature control, given the major considerations on the category of stock and the production system.

Where a house is more likely to experience a greater frequency of very light winds ($\leq$ 1 m/s at vent height) and high temperatures due to over-sheltering and/or aspect ACNV will have fewer attractions as the occupants will experience a greater degree of stress. This is especially true where, for example, fattening pigs on solid floors are being considered. High humidities at this time will compound the problem and increase the liklihood of unacceptable behaviour. In such cases a back-up fan ventilation system or larger than normal air inlet vents may have to be installed.

The importance of selecting a well exposed site where the air flow across the building is not unduly disturbed was detailed by Smith (1973) and the variables to be accounted for in the good husbandry of housed pigs are discussed at some length by Smith (1983).

Analysis of Critical Periods

To assess the frequency of occurrance of temperatures and windspeeds liable to cause discomfort, hourly meteorological records were analysed for the RAF stations at Leeming (Yorkshire), Shawbury (Shropshire) and Boscombe Down (Wiltshire) during the period 1972-81, but 1973-81 for Shawbury.

The windspeeds used are the mean values taken over an hour and recorded at the standard height of 10 metres above a grass covered surface. The temperatures are taken from standard screen readings. Figure 1 gives, for each site, the mean total of hours per annum when the stated limits for windspeed of 2 and 4 knots coincided with a temperature recording of 15, 17 or 19°C. for one or more hours.

It can be seen that these conditions are by no means uncommon and reference to the frequency of occurrence of 4 knots (2 m/s) winds may in many instances give a fairer reflection of the frequency of critical windspeeds at the vent height of a sheltered animal house (say 1 m/s or 2 knots at 3 metres). The more open aspect under which the 10 m windspeeds are recorded may thus be compensated for.

The site to site variability is also significant in that the values from Boscombe Down are generally lower than those from Leeming which in turn has many less hours selected than does Shawbury. If the assumption is made that these records are directly comparable (a fair assumption) then it is difficult to be specific on the causes of this variability. One influence which Shawbury, especially, and Leeming have that Boscombe does not is a large range of hills to the west of the area. By inducing a Fohn effect to the airflow over the hills, the temperatures could be expected to be a little higher, and the area may be more sheltered generally giving rise to a greater number of low windspeeds. The local topography is probably the main determining factor in that local funneling of the air flow will produce a unique effect for each site. The general nature of the surrounding vegetation will also influence the windspeeds through exerting a frictional drag on the air flow resulting in a corresponding increase or decrease in the general movement of the air.

From this variability between sites which are designed to give as near a standard exposure to the elements as possible, it is not hard to realise how critical is the correct siting of an animal house, to gain the maximum advantage from the natural environment.

Consecutive Hours

The odd hour or two when any specified criteria are satisfied may not be of sufficient length to have much significance. The consecutive nature of hours when the ambient conditions are considered critical is therefore of importance.

Figs 2 (a to f) gives for each combination of temperature and windspeed the percentage of the total number of hours per annum which are formed from occasions when 1 hour or more was recorded.

To take as an example a case when limits of 17° and 4 knots were taken for Leeming, and only periods of 3 consecutive hours or more were considered critical. Fig 1 indicates that a total of 85 hours could be expected each year, out of which Fig 2d indicates that 58% of these hours are formed by occasions of 3 consecutive hours or more, ie 49 hours. If 6 consecutive hours were necessary then only 12% (10 hours) would be expected in an average year. The variability about these mean values should not be disregarded, and a more exacting analysis would give more details on this.

Daily Frequency of Occurrence

The above values do not give much indication as to the number of days in each month in which one or more hours was found satisfying the set criteria.

During the planning stage the daily frequency of occurrence will have a bearing on any decision on whether to install a back-up ventilation system, and of what type.

For one of the weather combinations, temperatures $\geq 17^{\circ}C$ with mean hourly windspeeds of $\leq$ 4 knots, at Shawbury the daily frequency of occurrence was tallied, see Table 1.

Table 1 The number of days when the hourly temperature exceeded 17°C with a corresponding windspeed of ≤ 4 knots: Shawbury.

	Month							
Year	Apr	May	June	July	Aug	Sept	Oct	Total
1973	0	6	11	15	15	7	1	55
1974	0	4	4	1	8	1	0	18
1975	1	3	9	14	20	2	0	49
1976	0	3	15	9	18	1	0	46
1977	0	2	4	7	9	2	0	24
1978	0	7	3	7	5	3	2	27
1979	0	1	10	10	5	2	0	28
1980	1	3	5	8	9	4	0	30
1981	0	0	2	7	14	8	0	31
Total	2	29	63	78	103	30	3	308
Mean	< 1	3	7	9	11	3	< 1	34

Again the frequency at which the stated conditions are recorded is quite large, especially during August. The annual variability is also now apparent with the range of values for August going from 5 days up to 20, being a good case in point.

Conclusions

The frequency of occurrence of moderate to high temperatures, coinciding with low windspeeds has been shown on an hourly and daily basis to be quite large. There is also a marked variability between the sites chosen, with the variations not matching what might have been expected, ie an increase in occasions the further south being the site. This site variability has been put down to the local exposure and general environment of the sites in question.

The final decision on the type of structure and the inclusion or otherwise of a supplementary ventilation system may only be influenced in a small way by meteorological considerations, but the siting and exposure of that structure has been shown to be important. Poor siting and exposure could lead to a much higher incidence of conditions which will distress the residents unless the design criteria is appropriately modified.

Any comments or suggestions should be sent to the author.

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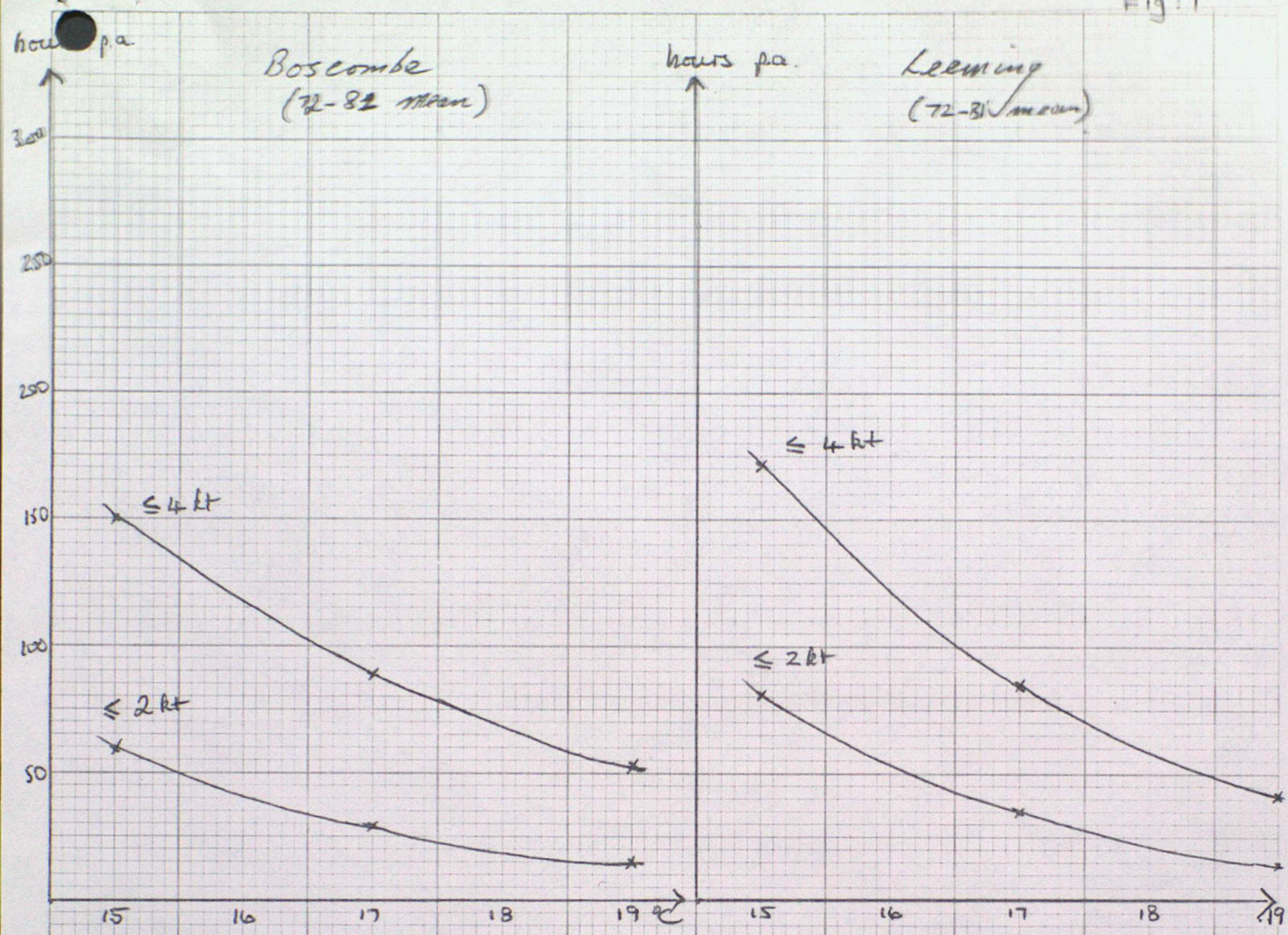
References

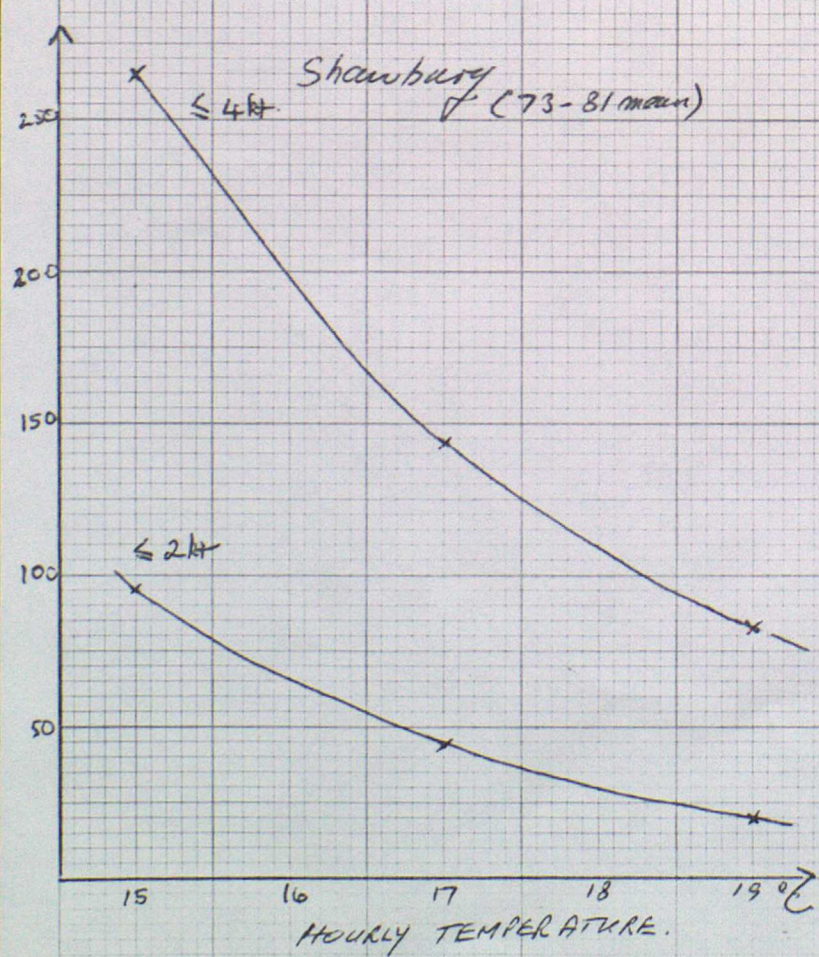
Bruce, J M 1973 Natural Ventilation by Stack Effect.
Farm Buildings Progress pp 23-28

Smith, A T 1983 Pigs - Environment
MAFF, Booklet (In Press)

Smith, C V 1973 Beef Housing Studies - Working Report I,
Agricultural Memorandum No 555.

Fig: 1



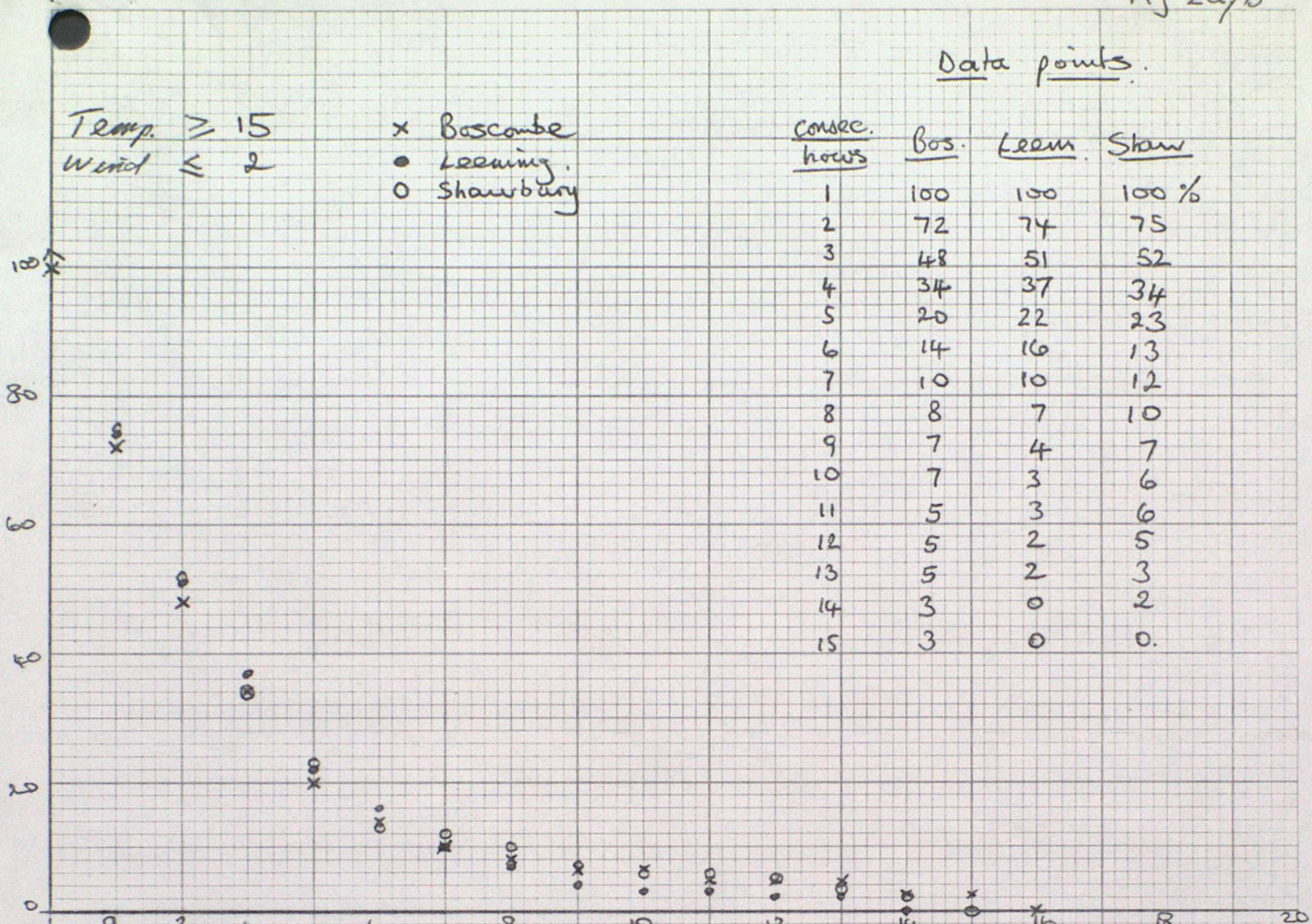


data points.

		Boscombe	Leeming	Shawbury
2kt	15°	59	81	96
	17°	29	35	44
	19°	15	14	20
4kt	15°	150	171	265
	17°	88	85	144
	19°	53	41	83

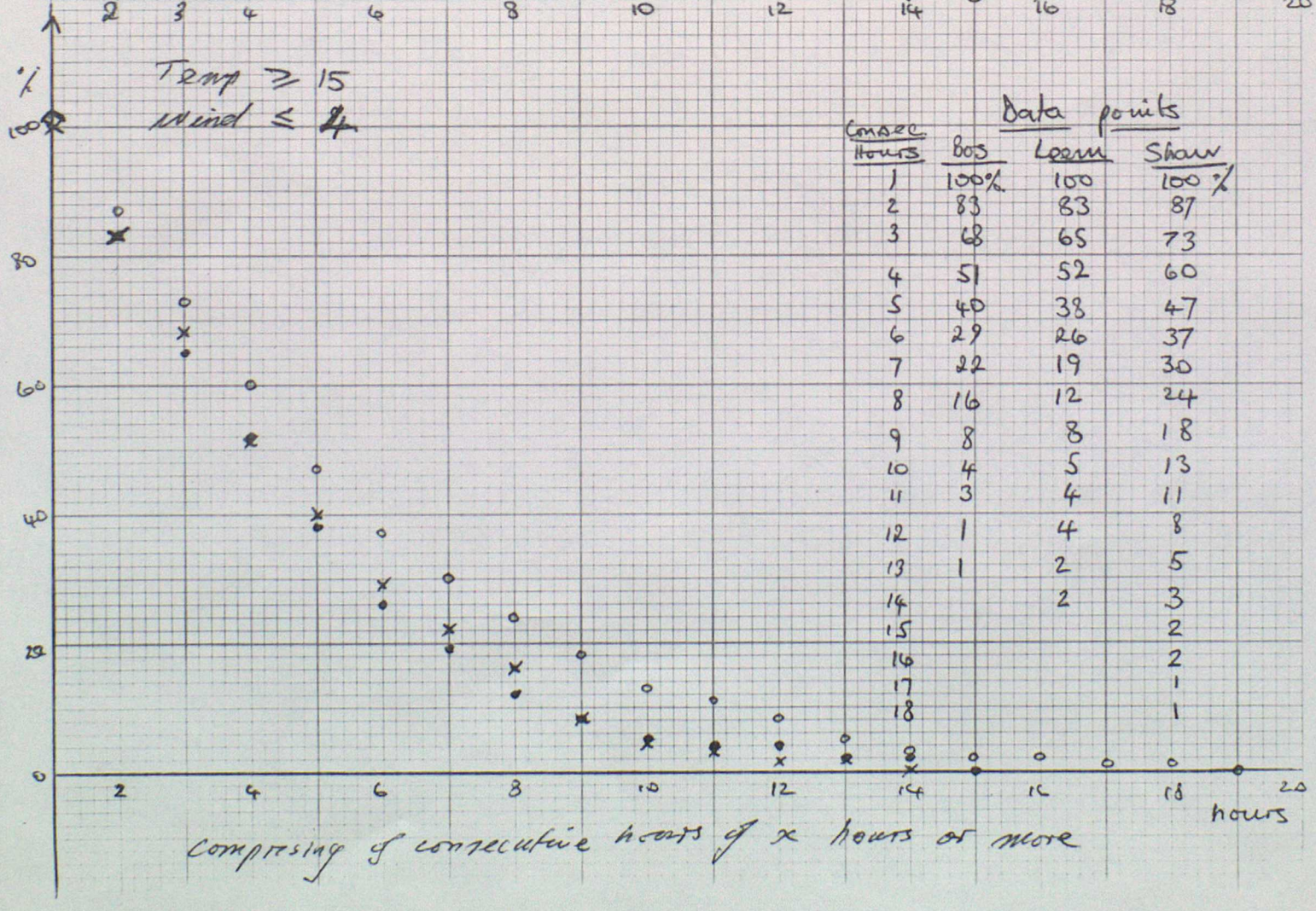
N°. of hours per year when temp. and windspeed criteria are met simultaneously.

Fig 2a/b



Data points.

Consec. hours	Bos.	Leem.	Shaw
1	100	100	100 %
2	72	74	75
3	48	51	52
4	34	37	34
5	20	22	23
6	14	16	13
7	10	10	12
8	8	7	10
9	7	4	7
10	7	3	6
11	5	3	6
12	5	2	5
13	5	2	3
14	3	0	2
15	3	0	0.

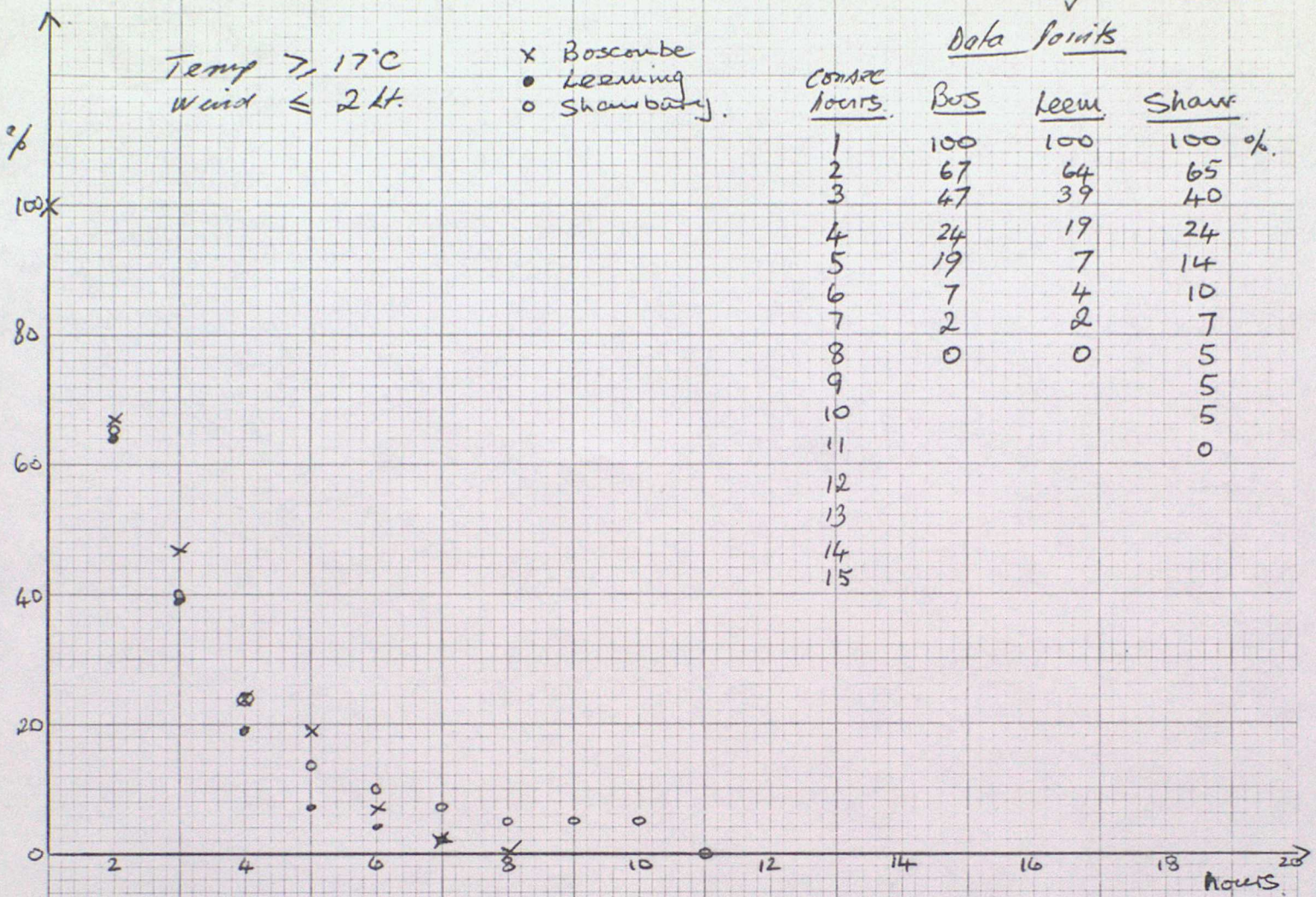


Data points

Consec. Hours	Bos	Leem	Shaw
1	100%	100	100 %
2	83	83	87
3	68	65	73
4	51	52	60
5	40	38	47
6	29	26	37
7	22	19	30
8	16	12	24
9	8	8	18
10	4	5	13
11	3	4	11
12	1	4	8
13	1	2	5
14		2	3
15			2
16			2
17			1
18			1

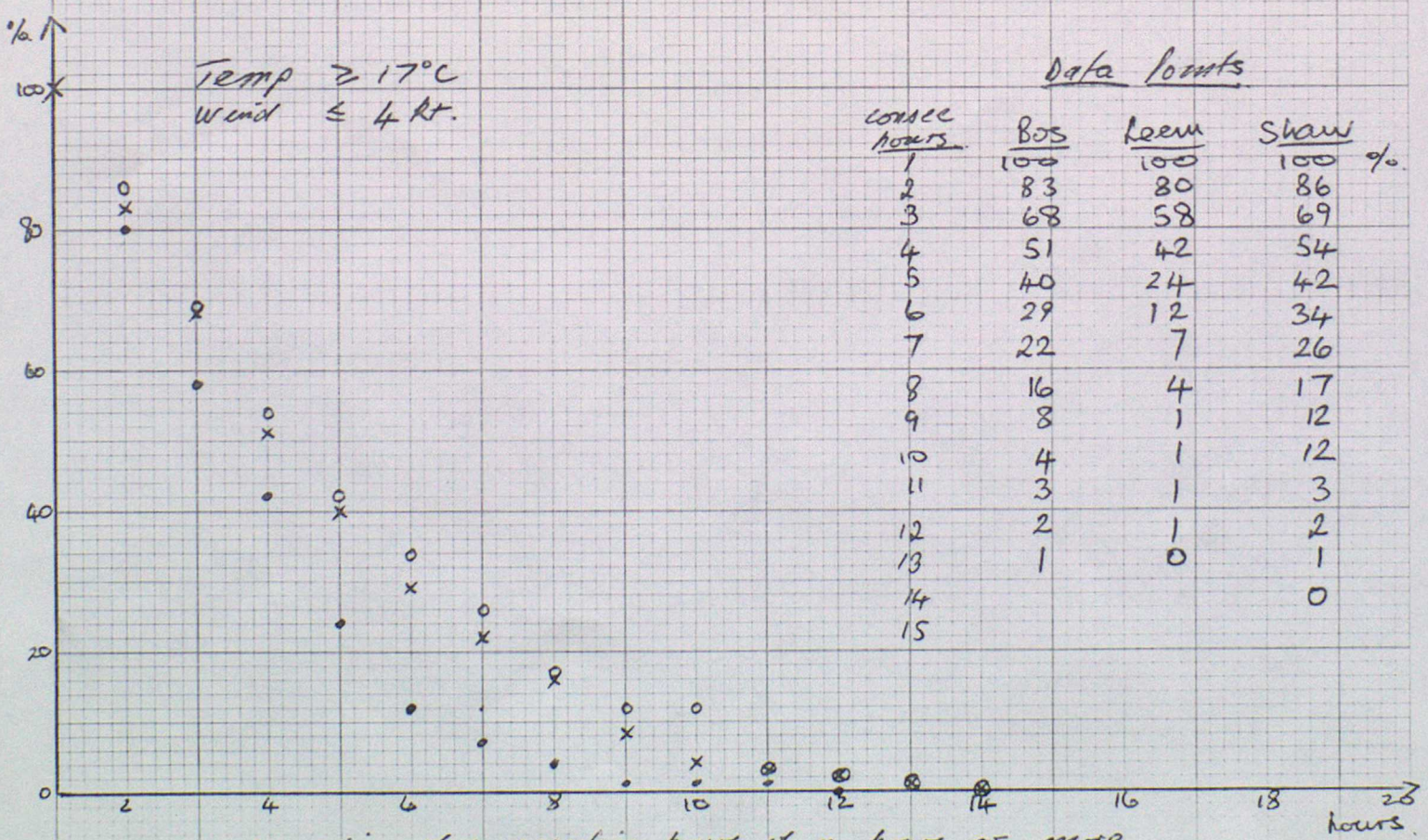
comprising of consecutive hours of x hours or more

Fig. 2 c/d.



Data points

consec hours	Bos	Leem	Shaw
1	100	100	100 %
2	67	64	65
3	47	39	40
4	24	19	24
5	19	7	14
6	7	4	10
7	2	2	7
8	0	0	5
9			5
10			5
11			0
12			
13			
14			
15			



Data points

consec hours	Bos	Leem	Shaw
1	100	100	100 %
2	83	80	86
3	68	58	69
4	51	42	54
5	40	24	42
6	29	12	34
7	22	7	26
8	16	4	17
9	8	1	12
10	4	1	12
11	3	1	3
12	2	1	2
13	1	0	1
14			0
15			

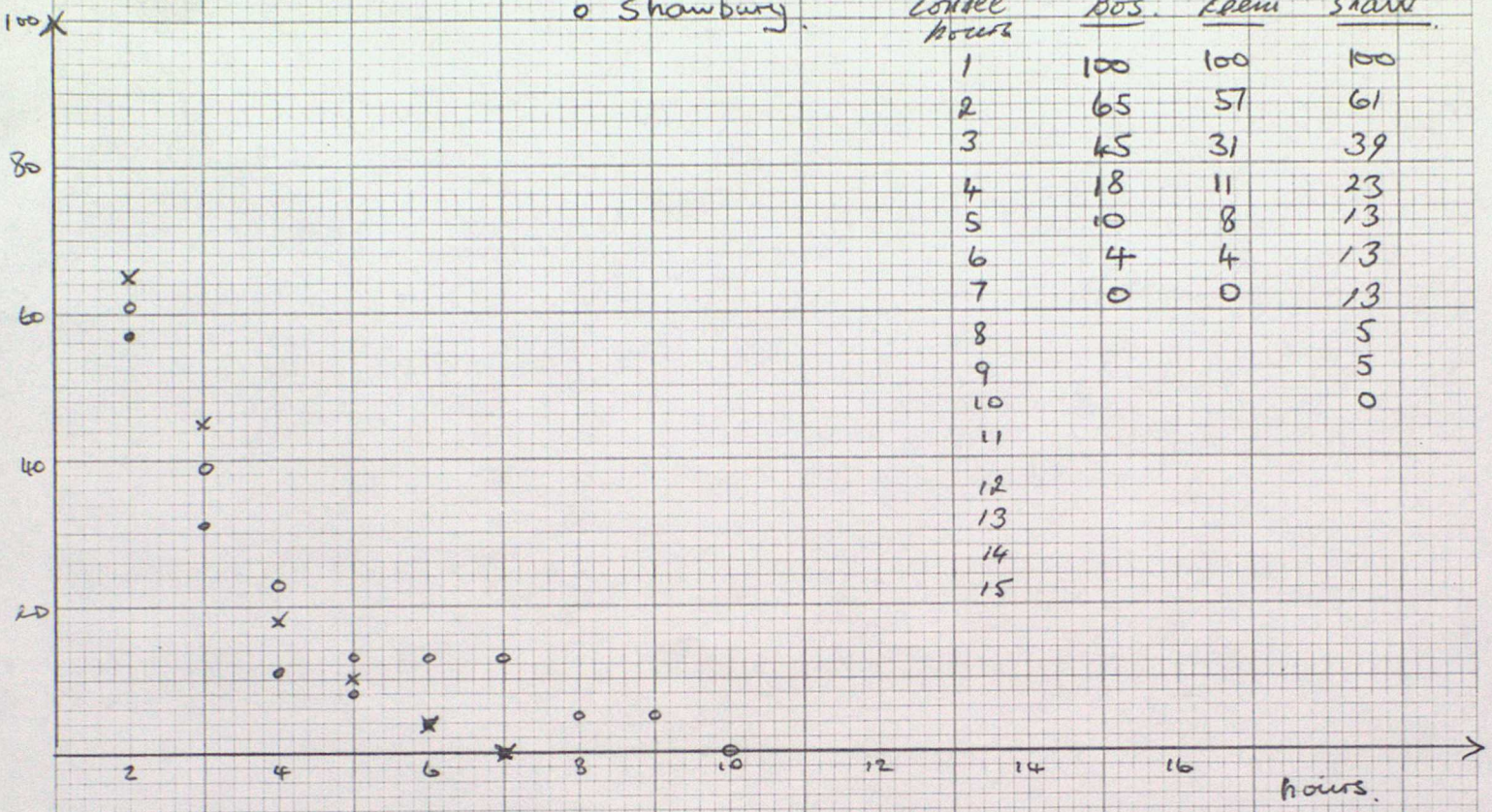
comprising of consecutive hours of x hours or more.

Fig 2e/f.

Temp ≥ 19 °C
Wind ≤ 2 kt.

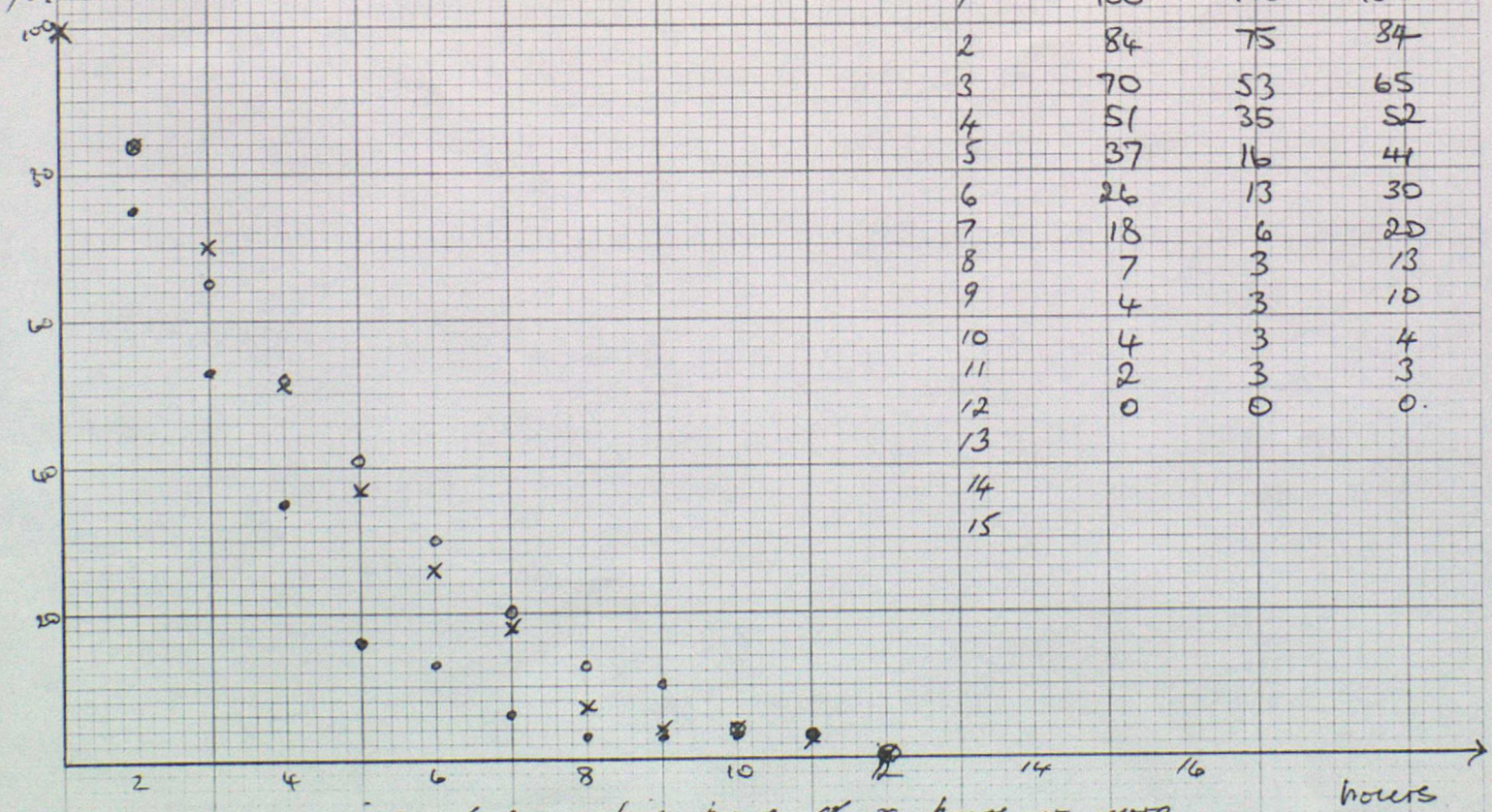
× Boscombe
• Leeming
○ Shawbury

Consec hours	data points × Bos.	• Leem	○ Shaw
1	100	100	100
2	65	57	61
3	45	31	39
4	18	11	23
5	10	8	13
6	4	4	13
7	0	0	13
8			5
9			5
10			0
11			
12			
13			
14			
15			



Temp ≥ 19 °C.
Wind ≤ 4 kt

Consec hours	data points × Bos.	• Leem	○ Shaw
1	100	100	100
2	84	75	84
3	70	53	65
4	51	35	52
5	37	16	44
6	26	13	30
7	18	6	20
8	7	3	13
9	4	3	10
10	4	3	4
11	2	3	3
12	0	0	0.
13			
14			
15			



comprising of consecutive hours of x hours or more.